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Inducing Conservation of Number, Weight, Volume, Area, and Mass in Pre-School Children.

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Descriptors-*Concept Teaching, *Conservation (Concept), *Experimental Programs, Geometric Concepts, Intelligence Quotient, Number Concepts, Preschool Children, Preschool Learning, *Preschool Programs, Weight

The major question this study attempted to answer was, "Can conservation of number, area, weight, mass, and volume to be induced and retained by 3- and 4-year-old children by structured instruction with a multivariate approach? Three nursery schools in Iowa City supplied subjects for this study. The Institute of Child Behavior and Development contributed 80 children; the University Parents Cooperative Pre-school contributed 52; and Iowa City Montessori Nursery School furnished 53. The Institute was selected as the control group; the University Parents Cooperative Pre-school comprised the experimental group, and the Montessori Nursery School children were used for the pilot study. An individual Stanford-Binet Intelligence test, a criterion pretest, and a posttest were administered. Criterion scores were based on one of two equivalent forms, each containing a 57-item conservation test, one test of rote counting, one test of rational counting, and a rating of attentiveness. The experimental group showed a significant gain over their own pretest scores in every subtest except one. The analysis indicated that gains by the experimental group in 16 of the 17 subtests were significantly greater than gains by the control group. The results showed conclusively that the concepts could be learned by 3- and 4-year-old children. (DO)

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INDUCING CONSERVATION OF NUMBER WEIGHT, VOLUME, AREA, AND MASS IN PRE-SCHOOL CHILDREN

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INDUCING CONSERVATION OF NUMBER,

WEIGHT, VOLUME, AREA, AND MASS IN PRE-SCHOOL CHILDREN

Numerous studies have been designed to investigate methods of inducing conservation of the various media using one or more variables. Generally, those studies that have employed only one variable, while yielding valuable insights into the learning process, reported negligible success in inducing conservation. Conversely, most of those studies that have reported significant results have used two or more variables. A particularly relevant investigation completed by Sonstroem, and reported by Bruner, clearly showed the interaction involved between the two variables, subject manipulation and labeling; subject manipulation being effective only when labeling was also present.

Problem

The problems posed by this study were:

1. Can conservation of number, area, weight, mass, and volume be induced and retained by three and four year-old children by structured instruction, using a multi-variate approach? Is instruction equally effective at all I.Q., C.A., and M.A. levels?
2. Does chronological age have a significant effect on level of conservation?
3. Does mental age have a significant effect on level of conservation?
4. Does intelligence have a significant effect on level of conservation?
5. What are the correlations among dimensions believed to constitute the concept of number (discrimination of number, cardinal number, discrimination of length, seriation, ordinal number, additive composition of number, multiplicative composition of number, and transitivity of number)?
6. What are the correlations among the major types of conservation (number; mass; weight; area; volume; and reversibility of mass, weight, and number)?
7. What is the correlation between conservation of number and rote counting?
8. What is the correlation between conservation of number and rational counting?
9. What is the correlation between conservation and attentiveness?

Method

Subjects. The study used the total population of three nursery schools (185 subjects) located in Iowa City, Iowa. The Institute of Child Behavior and Development, operated by The University of Iowa, contributed 80; The University Parents Cooperative Pre-school, associated with, but not operated by the university, contributed 52; and the Iowa City Montessori Nursery School furnished 53. There was no significant difference in the mean I.Q. among the three schools. The I.Q. range was 85 to 166. Chronological age ranged from 3-4 to 5-4, while mental age ranged from 3-1 to 8-5. The I.Q. mean was 122.

The Institute of Child Behavior and Development appeared to have an excellent program in quantitative concepts, therefore, it was selected as the control group. The University Parents Cooperative Pre-school comprised the experimental group and the Montesorri Nursery School children were used for the pilot study.

Pilot Study. During the pilot study, all 53 children in the Montesorri School were given both forms of the criterion test at pre-test. The equivalent forms reliability of this administration was .964. Later, a split-halves reliability was calculated on Form I at post-test which yielded a reliability of .966. A more efficient sequence of administration was developed which reduced administrative time from one and one-half hours to twenty-five minutes. An appropriate difficulty range was established and an item analysis was completed.

Tests. An individual Stanford-Binet Intelligence Test, a criterion pre-test, and a post-test were administered to all 185 subjects who participated in the study. All tests were administered individually by the same examiner in a separate room within each of the nursery schools.

The criterion test scores werebased on one of two equivalent forms, each of which contained a 57 item conservation test, one test of rote counting, one test of rational counting, and a rating of attentiveness. The conservation test was subdivided into seventeen subtests of 3 to 6 items each. Each subdivision was designed to include a different aspect of the concept of conservation and had a range of difficulty.

All conservation test items were taken directly from the tasks used by Piaget to identify and describe the hypothesized stages of development in conservation. In his original studies, it was emphasized that the materials used in the experiments were familiar to the subjects. In the present study, those materials which appeared to be less commonly known in the environment of the children, were modified from those used by Piaget. For example, in place of egg cups and eggs, doll plates with silverware and small transport trucks with cars were substituted in Form I and Form II respectively.

Materials used in Form I were: minature gumdrops, doll plates with silverware, 3 x 5 file cards, checkers, pennies, and 18 graduated wooden cylinders.

Materials used in Form II were: M & M candies, toy transport trucks with cars, jumbo crayons, erasers, peanuts in the shell, and 18 graduated wooden blocks. Plasticene clay, water, water tumblers and juice glasses, a tall narrow bottle and a short wide bottle, red cards showing area were used with both Form I and Form II, although the tasks differed.

The two forms of the criterion tests were alternated at the time of administration of the pre-test. At post-test, each subject was given the opposite form of the test from that which he had taken at pre-test. The subjects were tested in alphabetical order. Vocabulary was altered when necessary to insure communication. For example, "smallest" was changed to "littlest" or to "baby one".

An example of one of the sub-tests is as follows.

<u>Test for Conservation of Cardinal Number</u> (Unprovoked response)

Procedure - In each item the examiner first placed the objects into one-to-one correspondence, and then rearranged them.

Form I

Materials - Ten 3 x 5 file cards, ten red checkers, and 30 pennies.

Test Item - 13 A checker was placed on each of five cards and then removed and arranged into a short row of checkers. "Is there the same number of checkers as cards, or is there more of one than the other?"

14 Number of cards and checkers increased to ten and the entire operation repeated with the same questions being asked.

15 Thirty pennies were poured into a pile. Pennies were then divided saying, "One for you, one for me, etc." until the entire pile was divided. The piles were then rearranged so that one appeared wider than the other while the second appeared taller than the other. "Do we each have the same amount or does one of us have more than the other?"

Form II

Materials - Twelve blue erasers, twelve primary crayons, and 30 peanuts in the shell.

Test Item - 18 Six erasers were placed in a line on the table and six crayons placed beside them (one to one). Crayon row was shortened and the subject questioned as above.

19 Same procedure using 12 of each and shortening the eraser row.

20 Thirty peanuts in the shell were poured into a pile and divided. Questions were the same as in item 15, above.

Lessons. The variables used to induce conservation were: (a) reversibility, (b) perceptual screening and mental imagery, (c) physical manipulation by subject and examiner, (d) addition/subtraction; subtraction/addition, (e) compensatory operation, (f) verbal rule, (g) reinforcement, (h) cognitive conflict or equilibration, (i) identity, (j) labeling, and (k) verbal instruction.

The lessons consisted of eight held three days a week, Monday, Wednesday, and Friday over a two and one-half week period. The morning group was divided as evenly as possible into five groups of 4 or 5 students each, on the basis of their composite pre-test scores. The afternoon group was divided into four equal groups of six each, on the same basis. Fewer groups were formed in the afternoon because the school schedule allowed less total teaching time in the afternoon, and the afternoon children were the older group. A rotating lesson schedule was employed within both forenoon and afternoon. Each group was scheduled for a fifteen minute period. This included gathering the necessary children together, escorting them to one of the upper level activity rooms, distributing the materials , and returning the children to their original rooms at the close of the session. The same material was presented to each group, however, the length of teaching time varyed slightly from approximately eight minutes for the more mature children to twelve minutes for the younger ones. The younger children were somewhat slower in manipulating the materials and had many more interruptions such as, needing a shoe tied, losing a toy, not hearing what was said, etc. Interest in the lessons was very high for all groups.

An example of one of the lessons follows:

Lesson I

Topic - Conservation of number.

Materials - Doll plates, wrapped candies, and a small bowl.

Beginning procedure - A small plate was distributed to each child. Then a little bowl was placed in the center of the table and each child was given a wrapped candy and asked to lay it on his plate.

Lesson I (continued)

"Do we each have a plate?
Do we each have a candy? Now, everyone put his candy into the bowl. (c)
Were there as many pieces of candy as there were plates? (a, b)
Were there as many plates as there were candies? (a, b)
Were there the same number of plates as there were children? (a, b) Now take the candy back out so that we can be sure. (a, c, g) Put it back on your plate. Now, hold the candy in your hand and put the plate in the middle of the table. (c) Just lay the candy on the table in front of you. (c)
Are there the same number of candies as plates? (h) Are there as many? (h) Now, put your candies in a tiny pile in the middle of the plates. (c)
Are there the same number of plates as candy? (h) Take your plates back and put your candy back on them. (a, c)
Are there the same number of candies and plates? (g) Stack up the plates and put the candy in a row. (c)
Are there the same number of candies as plates? (with eyes closed) (b, h) Put your candy in the bowl again. (c) Now, I will take one piece of candy out and put it back into the sack. (d)
Will there be a piece of candy for every plate now? (b)
Why not? (f) Each person put his candy back on his plate. (c, g)
Are there the same number of candies as plates? (h)
What should be done?"(a) -Examiner does as children suggest and puts one back- (c, g)
"Now, are there the same amount? (h)
Why wasn't there enough for everyone? (d, f)
Put your plates in a line down the center of the table and your candies in a short line beside them. (h, c)
Are there the same number of candies as plates? (h) It looks as though there are more plates. I will take away enough plates to make the rows look the same. (d, c)
Now, are there the same number of plates as candies? (h, b) Put the candies and plates back in front of you to be sure. (a, c, g)
Are there the same number? (j, h)
What should we do? (f, d)
Why weren't there enough plates? (f) Stack your plates in the center of the table and lay the candy around the stack. (c) There doesn't appear to be enough plates for that many pieces of candy. I'll add two more. (d)
Will there be the same number of plates as candy?
Why not?" (f) -Replace plates and candies- (c, d)
"Are there the same number of plates as candies now? (h, g)
Why not? (f) Put extras back into the sack. Put your candies in a small circle. Now put your plates around the candy. (c) Take a good look at the plates and candies. Are there the same number of plates and candies? (h) Now each person take a piece of candy and put it on your plate to be sure they are the same, then you may eat the candy." (a, c, g)

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Results.

It was assumed that the control group was also gaining in conservation concepts during the instructional period. Therefore an analysis was made using an A x S Design, treatment by subjects, to determine whether both the experimental group and the control group made a significant gain over their respective pre-test scores.

The experimental group showed a significant gain over their own pre-test score in every subtest except discrimination of number. This task showed a substantial gain but it was not statistically significant.

The control group also showed a significant gain in nine of the seventeen subtests. Another analysis was then made to determine whether the gains made by the experimental group were significantly greater than those made by the control group. Sixteen of the seventeen subtests of conservation showed the difference in gain to be significant, and, in favor of the experimental group. The difference in gain in rational and rote counting was also significantly in favor of the experimental group. (See Table 1.)

To determine whether this gain in conservation could be retained, the mean composite conservation score of the group which was post-tested immediately following instruction was compared with that group post-tested three weeks later. Those subjects tested three weeks later showed no extinction, but on the contrary, showed a slightly higher mean than those tested immediately after instruction. The comparison was then repeated using gain scores. The same results appeared. Several further analyses were made, the results of which are displayed in Table 2 and in the summary which follows.

Summary.

1. Can conservation of number, area, weight, mass, and volume be induced and retained by three and four year-old children by structured instruction using a multi-variate approach? Is teaching conservation significantly more effective at one CA, MA, IQ level than another?

The results showed conclusively that these concepts can be learned by three and four year-old children. Findings further showed that children of this age range could make significant gains in all these areas and that this learning could be retained. This finding was consistent at IQ levels from 85-155, from MA levels 3 through 8, and for CA levels 3-5 through 5-5. The study showed no significant difference in rate of gain between any of the above mentioned levels.

2. Does chronological age have a significant effect on level of conservation?

The study showed a significant difference in total conservation between CA levels.

3. Does mental age have a significant effect on level of conservation?

The study showed a significant difference in total conservation between MA levels. Moreover, MA consistantly correlated more closely with conservation than did CA.

4. Does intelligence have a significant effect in total conservation between IQ levels?

The study showed a significant difference in total conservation between IQ levels, but, IQ consistantly correlated less closely with conservation than did either CA or MA.

5. What are the correlations among dimensions believed to constitute the concept of number?

The correlations are moderate and positive, ranging from .10 to .41. This may mean that they are relatively independent factors which are measuring separate abilities.

6. What are the correlations among the major types of conservation: number, mass, weight, area, volume, and reversibility in mass, weight, and number?

These correlations were about of the same order as those within the conservation of number. Among the areas of conservation, the correlations ranged from .08 (between reversibility and conservation of volume) to .65 between conservation of mass and volume.

7. What is the correlation between conservation of number and rote counting?

There was a rather strong positive correlation (.58) based on the composite group at pre-test.

8. What is the correlation between conservation of number and rational counting?

The correlation between conservation and rational counting was surprisingly similar to rote counting at pre-test for the composite group, being .58 for rote counting and .59 for rational counting. However, as knowledge increased, rote counting tended to drop out while the correlation between rational counting and conservation became higher. At post-test, the correlation between conservation and rote counting was .50 while conservation and rational counting correlated .64.

9. Is there a positive correlation between attentiveness and level of conservation?

The correlation between the conservation score and the attentiveness rating given each child by the examiner was .55.

Table 1.

TESTS IN WHICH THE EXPERIMENTAL GROUP MADE A SIGNIFICANT GAIN OVER THE GAIN OF THE CONTROL GROUP

Subtest	F ratio	Mean Gain	
		Exp.	Con.
Discrimination of Number	.05	.17	.13
Provoked correspondence	51.79 **	1.27	.13
Unprovoked correspondence	30.83 **	1.50	.32
Conservation of cardinal number	55.35 **	2.77	.45
Additive composition of number	30.66 **	2.29	.61
Discrimination of length	8.97 **	.85	.26
Seriation	8.88 **	1.27	.58
Conservation of ordinal number	15.24 **	1.54	.40
Multiplicative composition of number	9.30 **	1.40	.39
Conservation of number	99.90 **	10.40	2.83
Conservation of weight	76.29 **	1.69	-.04
Conservation of volume	54.12 **	2.85	.50
Conservation of area	22.12 **	.88	.08
Conservation of mass	72.90 **	1.60	.14
Reversibility of weight, volume, & mass	4.29 *	.46	.19
Composite conservation	208.55 **	17.85	3.69
Rote counting	9.12 **	2.42	.65
Rational counting	19.22 **	6.23	2.68

** Significant at .01 (1, 118 df)
* Significant at .05 (1, 118 df)

Table 2.

INTERCORRELATIONS OF CA, MA, IQ, AND 19 SUBTESTS
FOR THE TOTAL GROUP AT PRE-TEST

	1	2	3	4	5	6	7	8
1. CA	1.00							
2. MA	.69	1.00						
3. IQ	.12	.79	1.00					
4. Discrimination of Number	.34	.31	.14	1.00				
5. Provoked correspondence	.29	.30	.17	.24	1.00			
6. Unprovoked correspondence	.25	.36	.27	.10	.65	1.00		
7. Cardinal number	.29	.37	.25	.17	.87	.94	1.00	
8. Additive composition	.28	.50	.41	.22	.42	.51	.52	1.00
9. Discrimination of length	.41	.44	.27	.13	.21	.26	.27	.34
10. Seriation	.50	.52	.30	.26	.28	.31	.33	.41
11. Ordinal number	.47	.51	.29	.41	.31	.20	.27	.43
12. Multiplicative composition	.41	.40	.18	.21	.36	.38	.40	.26
13. Conservation of number	.59	.67	.40	.50	.62	.62	.68	.71
14. Conservation of weight	.10	.15	.09	.00	.27	.26	.29	.15
15. Conservation of volume	.28	.44	.34	.09	.29	.40	.39	.36
16. Conservation of area	.11	.18	.14	.05	.28	.33	.34	.40
17. Conservation of mass	.23	.42	.34	.03	.46	.42	.48	.44
18. Reversibility	.20	.22	.13	.14	.17	.16	.18	.14
19. Total conservation	.57	.68	.43	.43	.65	.66	.72	.72
20. Rote counting	.49	.56	.35	.37	.19	.14	.18	.39
21. Rational counting	.46	.53	.33	.34	.22	.17	.21	.37
22. Transitivity	.23	.24	.13	.16	.72	.80	.84	.50

9	10	11	12	13	14	15	16	17	18	19	20	21	22	
														1
														2
														3
														4
														5
														6
														7
														8
1.00														9
.38	1.00													10
.26	.56	1.00												11
.30	.42	.22	1.00											12
.53	.75	.72	.62	1.00										13
.07	.10	.08	.22	.21	1.00									14
.21	.30	.18	.19	.39	.27	1.00								15
.13	.31	.19	.12	.34	.32	.26	1.00							16
.14	.23	.14	.30	.41	.41	.64	.24	1.00						17
.05	.17	.12	.08	.20	.15	.08	.03	.21	1.00					18
.49	.71	.64	.59	.95	.40	.56	.46	.60	.29	1.00				19
.32	.54	.62	.23	.58	.06	.22	.26	.12	.17	.54	1.00			20
.29	.59	.63	.23	.59	.17	.15	.25	.13	.21	.56	.75	1.00		21
.18	.36	.28	.39	.64	.38	.44	.41	.49	.23	.68	.12	.17	1.00	22